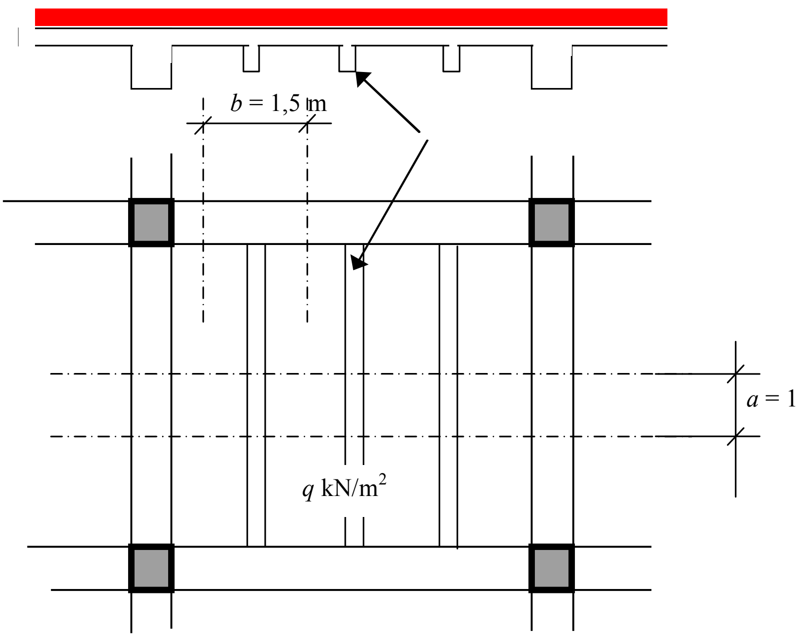
Assignment 1 - actions



Determine action on the beam for verification of the ultimate limit state. Axial distance of the beams is 1 to 2 m, cross section dimensions 0,45 × 0,20 m (including the slab thickness), slab thickness is 0,1 m. Consider the permanent load due to slab (volume weight is 25 kN/m3) and imposed load $q_k = 1{,}50$ kN/m². Partial factor for the permanent and imposed loads are $\gamma_G = 1{,}35$ and $\gamma_Q = 1{,}5$.

Solution of the assignment 1

The axial distance of the beams is assumed: 1,5 m

The characteristic loads:

Permanent from the slab $g = 1{,}5 \times 0{,}1 \times 25 = 3{,}75$ kN/m

from the beam $g_k = (0{,}45\text{-}0{,}1) \times 0{,}2 \times 25 = 1{,}75$ kN/m

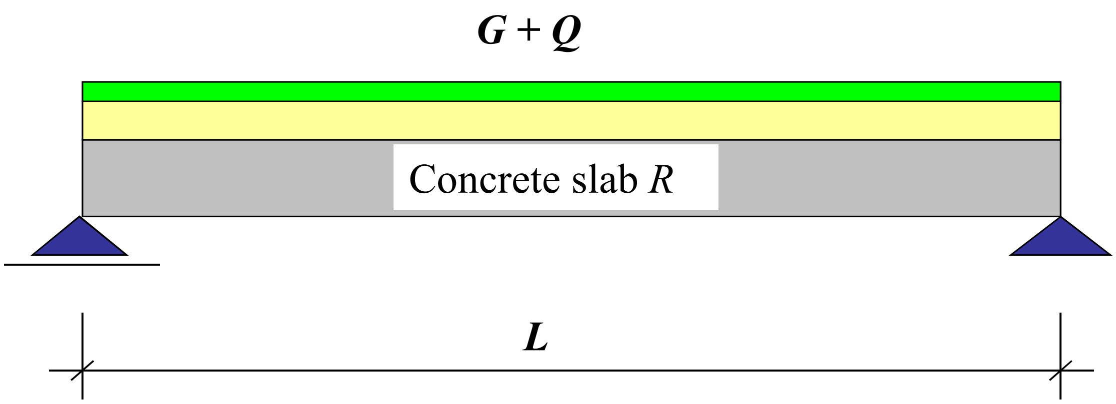
Permanent total $g_k = 5{,}5$ kN/m

Imposed load $q_k = 1{,}5 \times 1{,}5 = 2{,}25$ kN/m

Design load total:

$$p_d = g_k \times 1{,}35 + q_k \times 1{,}5 = 5{,}5 \times 1{,}35 + 2{,}25 \times 1{,}5 =$$
$$= 7{,}425 + 3{,}375 = 10{,}8 \text{ kN/m}$$

Assignment 2 – concrete slab



(1) Determine the maximum bending moment M_{Ed} of the simply supported reinforced concrete slab of the span L = 3 to 5 m exposed to permanent load due to own weight of the slab having the thickness $h \sim L/20$ m and imposed load 5 kN/m^2. Consider 1 m width of the slab (volume weight is 25 kN/m3), partial factor for the dead load $\gamma_G = 1,35$, for imposed load $\gamma_Q = 1,5$.

(2) Estimate reinforcement area A_s required for 1 m width of the slab using approximate formula $A_s \sim M_{Ed} /(z\, f_{yd})$, where $z \sim 0,9$ d and $d = h - 0,03$ m. Consider steel S 500 (the characteristic strength 500 MPa) and the partial factor for steel $\gamma_s = 1,15$.

Solution of the assignment 2

Assuming span L = 3 m:

(1) $M_{ed} = (25 \times 0,15 \times 1,35 + 5 \times 1,5) \times 3^2/8 = 14,13$ kNm

(2) $f_{yd} = f_{yk}/\gamma_s = 500 / 1,15 = 435$ MPa,

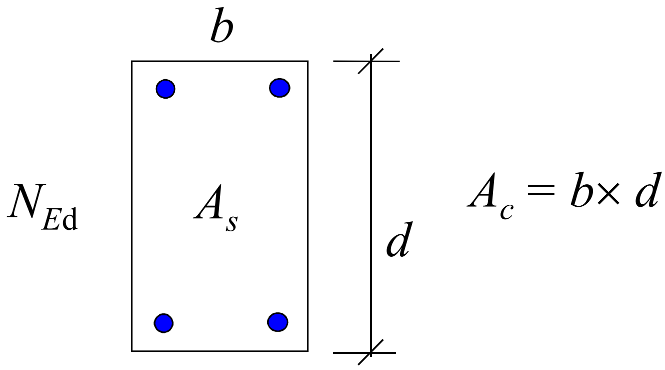
$d = h - 0,03 = 0,12$

$z \cong 0,9\, d = 0,9 \times 0,12 = 0,108$ m

$A_s \cong M_E/(z \times f_{yd}) = 0,01413/(0,108 \times 435) = 0,0003$ m^2

Assignment 3 – concrete column

Assess required reinforcement area A_s of a short reinforced concrete column 0,3×0,3 m exposed to the centric force N_{Ed}= 1500 kN, consider the characteristic strength of reinforcement f_{yk} = 500 MPa, the partial factor γ_s = 1,15, the characteristic strength of concrete f_{ck} = 20 MPa the partial factor γ_c = 1,5. The column resistance is $N_{Rd} = 0,8\, A_c f_{cd} + A_s f_{yd}$.

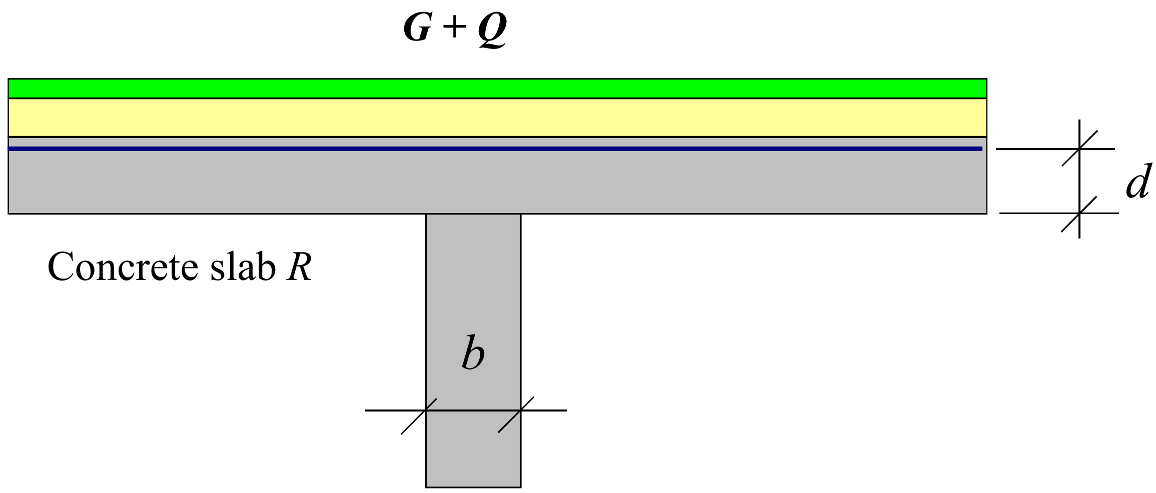


Solution of the assignment 3

- $f_{yd} = f_{yk}/\gamma_s$ = 500 / 1,15 = 435 MPa,
- $f_{cd} = f_{ck}/\gamma_s$ = 20 /1,5 = 13,3 MPa
- $N_{Ed} = N_{Rd} = 0,8\, A_c f_{cd} + A_s f_{yd} \rightarrow$
- A_s= (1,5 – 0,8×13.3×0,3×0,3)/435= 0,001247 m^2
- 0,003×0,3×0,3 = 0,00027< 0,001247 <

  < 0,08×0,3×0,3 = 0,0072 m^2

Assignment 4 – Punching shear



Verify resistance of the flat slab exposed to permanent load due to permanet load g_k = 7 kN/m^2 and imposed load q_k = 5 kN/m^2 (γ_G = 1,35, γ_Q = 1,5). Consider loading area 36 m^2. The effective depth of the slab is d = 0,15 m, design shear strength τ_c = 2 MPa. The slab is supported by a circular column of the diameter b = 0,30 m.

Solution of the assignment 4

The design shear force

$N_{Ed} = 36 \times (7 \times 1{,}35 + 5 \times 1{,}5) = 610{,}2$ kN

The critical perimeter

$u = \pi(b + 3d) = 3{,}14\ (0{,}3+3 \times 0{,}15) = 2{,}355$ m

The shear resistance

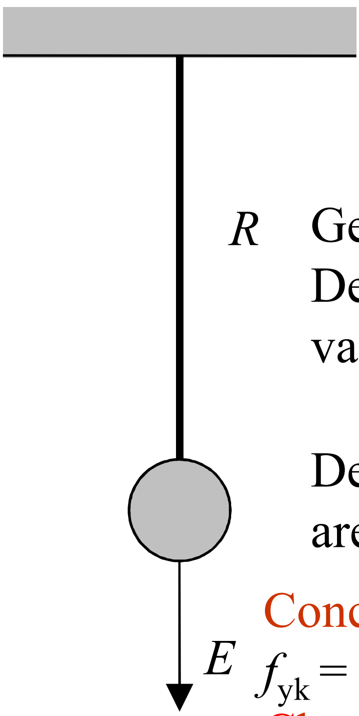
$V_{Rd1} = 2 \times 0{,}15 \times 2{,}355 = 706{,}5$ kN

$N_{Ed} < V_{Rd1}$

The slab is resistant against punching shear without special shear reinforcement

Assignment 5 – A steel rod

Specify section area A of a steel rod



	Load effect	Resistance
General	$E = G + Q$	$R = A\,f_y$
Design values	A: $E_d = \gamma_G G_k + \gamma_Q Q_k$	$R_d = A\,f_{yk}/\gamma_M = A\,f_{yd}$
	B: $E_d > \xi\,\gamma_G G_k + \gamma_Q Q_k$	
	$> \gamma_G G_k + \psi_0 \gamma_Q Q_k$	

Design of the area A **$E_d < R_d$ ⟹ $A > E_d / f_{yd}$,**

Concider : $\gamma_G = 1{,}35$, $\gamma_Q = 1{,}5$, $\xi = 0{,}85$, $\psi_0 = 0{,}7$, $\gamma_M = 1{,}10$

$f_{yk} = 235$ MPa, thus $f_{yd} = f_{yk}/\gamma_M = 214$ MPa

Choose your own values: $G_k \sim 0{,}6$ MN, $Q_k \sim 0{,}4$ MN,

A: $E_d = 1{,}35 \times 0{,}6 + 1{,}5 \times 0{,}4 = 1{,}41$ MN

B: $E_d = 1{,}35.0{,}6 + 0{,}7 \times 1{,}5 \times 0{,}4 = 1{,}23$ MN

A: $A > 1{,}41/214 = 0{,}00659\ \text{m}^2$

B: $A > 1{,}23/214 = 0{,}00574\ \text{cm}^2$ (= $0{,}87 \times 0{,}00659$)

Assignment 6 - Masonry

Specify resistance of a masonry wall (modify dimensions):

Fired bricks f_u =25 MPa, units I, production B, $\gamma_M = 2{,}2$

$K = 0{,}4$; $f_b = \delta f_u = 0{,}77 \times 25 = 19{,}25$ Mpa; M10: $f_m = 10$ Mpa

$f_k = 0{,}4 \times 19{,}25^{0{,}65} \times 10^{0{,}25} = 4{,}86$ MPa, $f_d = f_k/\gamma_M = 4{,}86/2{,}2 = 2{,}07$ MPa

$M = 0$, $e_{fi} = e_{fm} = 0$; $h_{ef} = 0{,}75 \times 3{,}3 = 2{,}5$ m, $b = 1$ m, $t = 0{,}44$ m

$$N_{Rd} = \Phi_{i,m} \times b \times t \times f_d = \Phi_{i,m} \times 0{,}911\ \text{MN}$$

Foot and head of the wall:

$e_a = h_{ef}/450 = 2{,}5/450 = 0{,}0055$ m

$e_i = e_{fi} + e_a = 0 + 0{,}0055$ ($\geq 0{,}05\,t$); $0{,}05\,t = 0{,}05 \times 0{,}44 = 0{,}022$ m

$e_i = 0{,}022$ m , $\Phi_i = 1 - 2\,e_i/t = 1 - 2 \times 0{,}022/0{,}44 = 0{,}9$

$$N_{Rd} = \Phi_i \times b \times t \times f_d = 0{,}9 \times 1 \times 0{,}44 \times 2{,}07 = 0{,}820\ \text{MN}$$

Middle of the wall:

$e_k = 0$, for $\alpha_{sec} = 1000$, $h_{ef}/t_{ef} = 5{,}64$ and $e_{mk}/t = 0{,}05$ graph: $\Phi_m = 0{,}88$

$$N_{Rd} = \Phi_m \times b \times t \times f_d = 0{,}88 \times 1 \times 0{,}44 \times 2{,}07 = 0{,}802\ \text{MN}$$